Preface

1. National Aeronautics and Space Administration (NASA)/ Department of Defense (DOD) policy is to achieve a consistent level of safety by applying reasonable criteria, giving the Space Shuttle Program (SSP) payload and ground support equipment (GSE) designer, operator, processor, and user the requirements to develop effective, efficient ground processing procedures usable at all SSP and cargo processing locations. This document aligns existing DOD and NASA ground safety criteria and establishes requirements for ground processing of SSP payloads and associated GSE. The requirements to assure payload mission success are the responsibility of the payload organization and are not within the scope of this document.

2. This document replaces the regular John F. Kennedy Space Center (KSC) handbook requirement for a preface signed at the directorate level and authorizes subordinate elements to implement the joint safety policies established in the "Space Shuttle Payload Ground Safety Handbook."

3. The Director, Kennedy Space Center, and the Commander, 45TH Space Wing, will assure compliance with these policies and approve waivers to the provisions of this Handbook.

4. The Handbook will be reviewed annually and changes incorporated that are mutually agreeable to the Director, KSC, and the Commander, 45 SPW.

5. This Handbook supersedes SAMTO HB S-100/KHB 1700.7A, 30 November 1984 issue.

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Handbook is to present the SSP payload ground safety policy and the criteria applicable to payload/GSE design and to ground processing from arrival to liftoff and during postlanding activities to qualify SSP payloads and associated GSE for safety certification by the payload organization to the Launch Site Safety Office (LSSO). It establishes SSP payload ground safety requirements by providing a single, common interpretation of 45 SPWR 127-1, "Range Safety Regulation," for the 45TH Space Wing (45 SPW) and KMI 1710.1, "Safety Program and Reliability and Quality Assurance Program," for Kennedy Space Center (KSC) requirements. This allows reciprocal operations at the Eastern Launch Site (ELS) after jointly acceptable safety certification is achieved. ELS consists of the SSP and the payload processing facilities at KSC and Cape Canaveral Air Station (CCAS).

1.2 SCOPE

This document establishes the minimum NASA/DOD ground processing safety policy, criteria, and requirements for SSP payloads and associated payload organization-provided portable GSE. It provides the detailed safety requirements for ground operations and payload/GSE design not contained in NASA Handbook, NSTS 1700.7, "Safety Policy and Requirements for Payloads Using the Space Transportation System." This document does not address facility GSE, non-SSP program elements, or flight safety. Specific implementation of design requirements is sometimes omitted to allow the payload organization flexibility in developing payload/GSE design. The payload organization's implementation of design requirements shall be coordinated with the LSSO. Associated Occupational Medicine and Environmental Health requirements have been selected and included in this document.

1.3 APPLICABILITY

This document applies to–

A. All organizations processing SSP payloads or experiments at the ELS. This includes all government organizations (i.e., NASA, DOD, other domestic, or foreign government or alliance organizations) and independent foreign or domestic enterprises.

B. Contractors in direct support of the above organizations.

C. Other organizations or agencies providing direct personnel and equipment interface to payload or payload GSE support.

D. Any of the above organizations that are required to support SSP payload postlanding operations at any landing site.

1.4 RESPONSIBILITY

The KSC Director and the 45 SPW Commander have been assigned overall authority for safety for all SSP payload activities conducted at their respective centers.

A. The officials of the LSSO responsible for implementing the safety policy and criteria for SSP payload activities are identified below:

1) For KSC, Director of Safety, Reliability and Quality Assurance (RQ).

2) For CCAS, 45 SPW Director of Safety (SE).

B. The Chiefs, Biomedical and Bioenvironmental Engineering Offices, are responsible for certain activities as identified in this Handbook. Office contacts are identified below:

1) For KSC, Biomedical Operations & Research Office (MD).

2) For CCAS, Bioenvironmental Engineering Office (USAF Hospital/SG, Patrick AFB).

1.4.1 Delegation

The Launch Site Safety Representative (LSSR) is the designated representative of the LSSO and has been delegated the following authorities:

A. Monitors LSSO-selected operations and has safety approval authority for procedural deviations.

B. Gives concurrence to start these selected operations.

C. May halt any operation deemed unsafe.

1.5 CHANGES

This Handbook will be reviewed annually in accordance with appropriate directives or as required by reference document changes. Changes to this Handbook shall be directed to and require joint agreement between the KSC Director and the 45 SPW Commander.

All documents referenced in the text of this document are by the basic number. The revision level and date of the referenced document are identified in Appendix B and are updated by the required review process.

2.0 PHASE SAFETY REVIEWS

The payload organization personnel are responsible for the safety of their own systems and personnel. They are also responsible to the SSP operator and the launch site operator not to compromise the safety of the other SSP payloads, the Orbiter, launch site facilities, and personnel. To implement this safety effort, the NASA and DOD programs of phase safety reviews are implemented by Johnson Space Center (JSC) document, NSTS 13830, "Implementation Procedure for NSTS Payloads System Safety Requirements," and by Space Division Regulation, SDR 127-8, Vol. I, "Safety Certification Procedures for DOD National Space Transportation System Payloads." These procedures provide for an early safety interface to be established between the payload organization and the launch site.

The phase safety reviews are conducted by a team of representatives from many different backgrounds to provide a broad spectrum of knowledge on the subject of safety. It is their task to advise payload organizations on matters of system safety. Included in this team are representatives of the processing sites. It is their task, in addition to the above, to verify that the payload and its support equipment comply with the requirements of this document.

NASA normally conducts flight safety reviews for the payload at JSC and a separate ground safety review on ground operations and GSE design at KSC. They may, however, be held concurrently at either site or at a site jointly agreed on by JSC and KSC. DOD normally conducts their reviews concurrently at the contractor's facility but may select an alternate site. These reviews provide for the delivery of safety documentation that is required by the launch site prior to delivery of the payload to that site. This documentation is further discussed in Paragraph 3.0 of this document. In the past, some payload organizations have not fully understood the extent of these data requirements, and this has created problems. The procedures explained and outlined in this text preclude these problems and bring about a smooth transition from the factory to the launch site, through the launch and, if applicable, through recovery.

The documentation requirements of this document and the phase safety reviews will be based upon the hazardous nature and degree of complexity of the payload systems. When flight payload safety reviews and ground payload reviews are separate reviews, an assessment shall be made by the payload organization to assure that hazards identified in each package are assessed for applicability to the other; e.g., if a ground safety hazard report on inadvertent thruster firing does not exist, the flight safety hazard report must be referenced in the ground safety package and it must contain a discussion of the applicability of the flight safety controls on ground safety.

3.0 DOCUMENTATION

3.1 GENERAL

The LSSO requires documentation to assure safety compliance of payload/GSE design and safe ground operations for the SSP payloads. Identification, submittal, and approval of the documentation required by NSTS 13830 for NASA and NASA-sponsored payloads, and by SDR 127-8, Vol. I, for DOD and DOD-sponsored payloads is accomplished by the phase safety review process. Documentation submitted shall be consistent with the phase level under review and be approved prior to completion of the Phase III Safety Review.

3.2 PHASE SAFETY REVIEW DOCUMENTATION

Phase safety reviews allow the participating parties to put into perspective the safety impact that the design concepts presented by the payload organization will have on the Shuttle, other payloads, and launch site processing facilities. The payload organization must demonstrate to the LSSO that hazards not eliminated by design exist for valid technical reasons and are not for operational convenience or cost savings. These hazards can cause operational restrictions that could limit personnel numbers, require a specific sequence of operations, or limit operations to specific facilities. The LSSO will communicate to the payload organization the rationale for any restrictions imposed as early as possible and will assist the payload organization in determining the course of action which can best serve operational efficiency.

The payload organization shall, in accordance with NSTS 13830 or SDR 127-8, Vol. I, provide the Safety Review Panel the following data consistent with the program phase:

A. Block diagrams, schematics, and descriptions of safety-critical subsystems. This includes tables of design and operating parameters for such items as lifting equipment, pressure systems, ordnance, and batteries.

B. Launch site processing plan including timelines for handling, storage, assembly, servicing, and checkout operations.

C. List of Technical Operating Procedures (TOP's), a synopsis of each procedure, and their preliminary classifications; i.e., hazardous or nonhazardous.

D. Documentation certifying compliance with ionizing and nonionizing radiation control requirements.

E. Hazard reports addressing both design and operations.

F. Failure/accident summary reports.

G. Copies of all noncompliance reports.

H. Ordnance storage and handling data requirements in accordance with Appendix D.

I. A list of all hazardous materials and physical agents. Material Safety Data Sheets (MSDS's) (CFR 1910.1200) shall be provided to the LSSO for all material and agents brought to the ELS by the payload organization.

J. A list of all plastic films, quantity, and location of use.

K. List of the payload T-O Umbilical functions.

L. Critical software commands must be identified and managed. These critical software commands include commands which, if executed or executed out of sequence, would create a hazardous condition or would remove a safety inhibit.

3.3 LAUNCH SITE DOCUMENTATION

The LSSO requires assurance, in the form of detailed documentation, that the payload organization is cognizant of and has the means to implement the safety and health policies and requirements of the launch sites. For example, Facility Safety Plans and Emergency Procedure Documents (EPD's) developed by the launch sites contain specific requirements for specific hazardous processing facilities/areas and are mandatory for all facility/area users. (See Appendix E for a listing of Facility Safety Plans and EPD's).

3.3.1 Payload Organization Launch Site Safety Plan

The payload organization Launch Site Safety Plan will demonstrate the means by which the organization manages and interfaces safety within its organization and how it applies the launch site safety requirements. For DOD and DOD-sponsored payloads, the format and content of the plan shall comply with the requirements of the payload organization's Launch Base Test Plan, Section 7 (ELS). For NASA and NASA-sponsored payloads, the specifics of the plan contents will be identified to the payload organization early in the phase safety review process. All plans shall be tailored to the complexity of the payload element and be provided to the LSSO for review and approval at least 30 days prior to first hardware delivery to the launch site.

3.3.2 Technical Operating Procedures (TOP's)

In order to be accomplished in a safe and orderly manner, payload ground operations must be conducted using detailed step-by-step instructions in TOP's. All TOP's designated hazardous by the LSSO or by the payload organization are required to be approved by the LSSO and published and "on the shelf" 30 days prior to use (10 days prior to use for revisions). For TOP's which are performed on CCAFS, an additional 30 days must be allowed for 45 SPW review. Draft or

preliminary procedures should be submitted to the LSSO when available. Where procedures are used to control hazards identified in the hazard reports, a listing of those procedures and the applicable step numbers which control the hazard shall be identified in the Phase III data package. Guidelines for hazardous classification of procedures are provided in Paragraph 4.l.3. LSSO guidelines and requirements for the preparation of TOP's can be found in Appendix C.

3.3.3 Payload Safety Noncompliance Reports

The payload organization must comply with all the requirements of this Handbook and of NSTS l700.7 or obtain an approved waiver/deviation for each case of inability to comply with a specific safety requirement. Waiver/Deviation requests shall be documented in accordance with requirements referenced in Paragraph 3.l. The LSSO will coordinate the requests and provide rationale for approval or disapproval to the appropriate authority. Launch site waivers/deviations shall be granted only by authority of the KSC Director or 45 SPW Commander and are not transferable between centers or payload activities. Payload organizations will be formally notified of the disposition of the waiver/deviation request.

3.3.3.1 Waivers - Each waiver request shall be limited to a specific subsystem or component in a specific application.

The payload organization is responsible for correcting the waived condition prior to the reflight of the payload on another Space Shuttle mission or the flight of subsequent payloads of the same series. If the waived condition is not corrected, a new waiver request is required. The new request must contain additional rationale, justifying continued noncompliance, and a copy of the original waiver must be attached.
Waiver requests should be submitted as soon as the need is identified. Prior to submittal, all waiver requests should be coordinated with the appropriate governmental sponsor and submitted to the LSSO. The waiver request shall contain the following:

A. The payload name and the model of the payload or support equipment as applicable.

B. The specific component and the subsystem in which the component functions shall be identified.

C. The specific requirement (one per waiver) and document and paragraph number against which the waiver is being sought.

D. The hazard created by noncompliance to this requirement and a cross-reference to the related hazard report. (The related hazard report should reference the waiver).

E. Reason for noncompliance to this requirement.

F. Give rationale for acceptance of this waiver, including any required support data and drawings, and list possible methods and techniques used in mitigating the hazards.

G. This waiver request must be signed by the program manager of the payload organization.

3.3.3.2 Deviations - When a deviation is granted, the noncompliance condition may be approved for more than one mission. Deviations will be applicable where the associated hazard to the Space Shuttle is not affected by manifesting with other SSP payloads, location of the payload in the Orbiter, or mission-unique environmental conditions. Noncompliance reports to be considered for a deviation will be those where the design, procedure, configuration, etc., do not comply with the safety requirement in the exact manner specified, but the intent of the requirement has been satisfied and a comparable or higher degree of safety is achieved.

3.4 DOCUMENTATION CHANGES

Changes or modifications which affect any approved phase safety review or launch site documentation must be provided to the LSSO for review and reapproval.

4.0 SAFETY REQUIREMENTS

Payload organizations shall comply with the following policies, practices, and regulations.

4.1 OPERATIONAL CONSIDERATIONS

4.1.1 Failure Tolerance

The interaction of payload, GSE, launch site facilities, and operator monitoring/intervention must tolerate a minimum number of credible failures and/or operator errors as determined by the hazard level analyses. This applies when failure to perform a function or the inadvertent performance of a function results in a hazardous event. The requirements contained in Section 4 are intended to provide the proper failure tolerance for GSE when used alone or in conjunction with a payload and/or facility. Verification of compliance with the technical requirements of this document will normally demonstrate the intent of this paragraph. When the technical requirements do not provide for failure tolerance, the adequacy of the controls shall be determined during the safety review process.

4.1.2 Personnel Policies

Payload organizations shall provide a description of their Training/Certification Program to the LSSO as part of the payload organization Launch Site Safety Plan. This program shall specify the personnel training required and the certification procedures employed to establish acceptable skill levels for all personnel involved in the ground processing of SSP payloads and GSE. Ground processing shall be performed only by persons certified in the discipline required for that process.

4.1.2.1 Training - Safety and health inputs to training programs shall be tailored to the task categories involved and included in lesson plans and examinations. Safety training of operating personnel is the responsibility of the payload organization. The payload organization shall meet the applicable facility and operating site requirements. It should be noted that there are certain launch site safety training requirements which are necessary in the process of obtaining area badging permits. Safety training will include such subjects as the following:

A. Hazard types, recognition, causes, and effects.

B. Prevention and control measures.

C. Safe operating procedures.

D. Checklists.

E. Safeguards and safety devices.

F. Personal protective equipment.

G. Monitoring and warning devices.

H. Emergency and contingency procedures.

4.1.2.2 Certification - The payload organization shall provide a list to the LSSO prior to commencement of hazardous operations of all personnel authorized to participate in hazardous operations certifying each individual's training and qualification by system to perform a specific hazardous operation.

4.1.2.3 Physical Examination - Personnel performing selected hazardous operations are required to have up-to-date physical examinations which meet the requirements of the cognizant medical office. Examples of personnel who require these examinations include ordnance workers, crane operators, propellant handlers, Propellant Handlers Ensemble (PHE) operators, and personnel working with certain types of ionizing and nonionizing radiation. The requirements necessary to satisfy this examination may be obtained from the cognizant medical office and the individual examination records must be furnished to that office.

4.1.2.4 Safety Enforcement - The payload organization will describe the means by which occupational and operational safety requirements of the launch site and this Handbook are enforced; it will address how violations of safety requirements are handled within the organization and what measures will be taken to preclude further violations.

4.1.3 Hazardous Operations

A. A ground processing activity is classified as hazardous based on the following considerations:

1) Energy is involved and loss of control could result in injury to personnel or damage to equipment.

2) A significant change from ambient condition will occur; e.g., increase or decrease of oxygen content, pressure, or temperature.

3) Presence of hazardous materials or physical agents which presents potential exposure to personnel.

B. TOP's are required for any activity, either by itself or in combination with another, which can result in injury to personnel or damage to property involving, but not limited to, the following:

1) Work Area/Environment.

2) Ordnance.

3) Propellants.

4) Cryogenics.

5) Lifting/Handling.

6) Radiation.

7) Toxics/Combustibles/Corrosives.

8) Pressure.

9) Electrical.

C. All hazardous or LSSO designated procedures require notification of the LSSR at least 24 hours prior to their performance. The LSSR will monitor all or selected sections of these procedures.

D. Concurrent hazardous operations within the same hazard control area are prohibited.

E. Concurrent operations within a hazard control area require LSSR or LSSO approval.

4.1.4 Safety Inspection

LSSR and payload organizations shall perform joint systematic safety inspections of the facility, working environment, related GSE, and any work in progress which could cause accidental injury to personnel or damage to hardware. Primary emphasis will include payload/GSE, critical processing equipment, facility maintenance status and associated equipment locations, and facility ingress/egress provisions and routing. Discrepancies identified from any of the inspections shall be corrected by the appropriate organization prior to conducting hazardous operations or bringing hazardous materials into the area. These safety inspections shall be performed on payload processing facilities at the following minimum times:

A. Prior to payload/GSE installation in the facility.

B. Immediately after installation of payload/GSE.

C. Immediately before the start of LSSO selected hazardous operations.

D. After any facility or equipment modification which may affect hazard potential.

4.1.5 Safety Equipment

The payload organization shall ensure that personnel protection is provided when engineering controls alone are not adequate to provide sufficient employee protection. Payload processing activities which are considered normal to general industry shall be in compliance with the requirements of accepted industrial safety practices. Payload processing operations which require personal protective equipment are identified in the appropriate sections of this Handbook.

The payload organization is required to review with the LSSO and Biomedical Office those operations not specifically identified which might require personal protective equipment. All personal protective equipment shall be approved by the LSSO and Biomedical Office.

4.1.6 Tools

4.1.6.1 Temporary Restraints - Temporary restraints, such as tethers, shall be used for individual tools to prevent misplacement or loss in critical areas when working above personnel or sensitive equipment. KMI 5330.8 establishes requirements and assigns responsibilities for the implementation and maintenance of an effective tool control program at the KSC.

4.1.6.2 Control of Tools - All tools and related equipment used in the proximity of flight articles shall be controlled to minimize the potential for foreign object damage. The payload organization shall identify the means to implement this requirement.

4.1.7 Photography

Camera permits are required for all photographic operations in controlled areas. The LSSO requires that the use of photographic lighting equipment (e.g., flashbulbs, strobe lights, and photofloods) be restricted within 100 feet of the Orbiter/payload whenever they are loaded with any propellant, within 100 feet of a propellant storage tank, and within 10 feet of exposed solid propellants. Photo equipment used above a payload must be tethered and the light sources shielded to prevent debris from falling onto the payload. The payload organization shall obtain LSSO approval to use photographic equipment in these and other hazardous atmosphere locations.

4.2 PERSONNEL SAFETY

The payload organization shall ensure a safe and healthful working environment through good design, effective training, and appropriate personal protective equipment.

4.2.1 Human Factors

Since human factors affect the interface between personnel and equipment, the payload organization shall consider human factors in the design of GSE and the payload. MIL-STD-1472 and NASA-STD-3000 contain guidance on human factors engineering and should be used in the design of GSE. Potential hazards resulting from the human interface shall be addressed by the payload organization during the Phase Review Process. To minimize the effects of these hazards, the following criteria shall be applied in the design and development of the payload, GSE, and ground operations.

4.2.1.1 Human Error - Consideration shall be given to the potential for human error in the personnel/equipment interface. Controls shall be instituted to prevent a hazardous condition which may result from such actions as mismating a connector, throwing the wrong switch, misreading a gauge, etc. Controls shall be instituted via design rather than procedural control where feasible. All equipment controls shall be labeled.

4.2.1.2 Noise - The payload organization shall implement a hearing conservation program to provide hearing protection for any noise levels of 85 decibels A-scale (dBA) or greater, regardless of the length of exposure. Where noise levels occur on intervals of 1 second or less, they shall be considered continuous. When personnel are exposed to sound exceeding those levels, feasible engineering or operational controls shall be utilized. If such controls fail to reduce sound levels to an acceptable level, personal protective equipment shall be provided and used. Exposure to impulsive or impact noise shall not exceed 140 decibels (dB).

4.2.1.3 Hazardous Materials - The payload organization shall assure through design/procedural controls that payload/ground processing GSE and operations will not expose personnel to hazardous materials in excess of the limits specified by the cognizant Biomedical Office.

4.2.1.4 Physical -

A. Accidental contact with sharp surfaces or protrusions shall be prevented by the use of ductile materials, energy absorbing devices, shields, rounded corners, and flush-mounted features. Sharp surfaces or protrusions include edges, crevices, points, burrs, wire ends, screw heads, corners, brackets, rivets, braided cable, cable swages, cable strands, clamps, pins, latches, lap joints, bolt ends, lock nuts, etc., which if contacted, could injure operating personnel.

B. Hazards shall not be created by the inaccessibility of flight or ground hardware. Physical access for safety critical operations or maintenance functions shall be provided. Protrusions which create a hazard such as hoses, wave guides, cables, brackets, etc., which cannot be eliminated by design, shall be made to be removable during service or maintenance functions.

C. Moving parts such as fans, belt drives, turbine wheels, and similar components that could cause personnel injury or equipment damage due to inadvertent contact or entrapment of floating objects shall be provided with guards or other protective devices.

D. Wherever possible, equipment requiring adjustment during its operation shall have external adjustment provisions and provide electrical shock protection when applicable.

E. GSE shall be designed to minimize the requirement for operations and maintenance personnel to wear protective clothing during normal operations and maintenance. Valves, gauges, levers, bolts, nuts, and any other item required to be moved, turned, manipulated, or monitored by personnel in protective equipment shall be sized to facilitate operation. Such items should be located to optimize access to the item while the operator is in a standing position. Sufficient clearance should be provided to preclude brushing against other surfaces. Suitable provisions to prevent damaging the protective equipment and to prevent personnel fatigue and discomfort shall be included in the GSE design.

F. All GSE designs should include a center-of-gravity analysis to ensure that the GSE/flight hardware does not tip, fall, slide, or allow for any type of sudden load shift.

4.2.1.5 Temperature - The payload organization shall protect personnel from equipment which can generate high or low temperatures greater than 45^{o}C (113^{o}F) or less than 0^{o}C (32^{o}F). This equipment shall be shielded, insulated, isolated, and/or oriented away from personnel and labeled to warn them of the danger.

4.2.1.6 Radiation - The payload organization shall advise and protect personnel from equipment which radiates ionizing or non-ionizing radiation.

4.3 PAYLOADS AND GROUND SUPPORT EQUIPMENT (GSE)

4.3.1 Biomedical Subsystems

Hazardous biomedical subsystems consist of medical experiment equipment designed to obtain data on man's adaptation and performance in the space environment. They also consist of scientific equipment designed to obtain experimental data on the effects of space environments on microorganisms, plant, and animal life. The payload operator shall provide complete handling procedures for all hazardous biomedical subsystems.

4.3.2 Electrical

All electrical equipment shall meet the requirements of this section to preclude hazardous conditions.

4.3.2.1 Electrical Requirements -

A. Electrical connectors shall be designed to make it physically impossible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be

created. These connectors for energized circuits must also be of "scoop-proof" design so that a partial inadvertent mismate will not provide pin-to-pin contact.

B. Electrical equipment shall not cause ignition of adjacent materials. The requirements for explosion/ hazardproofing at the launch site are identified in Paragraphs 4.4.2.3 and 4.4.2.4.

C. Malfunction of the payload or GSE circuitry shall not induce overload into the Orbiter, GSE, or facility electrical systems.

D. Electrical equipment shall be designed to provide personnel protection from accidental contact with alternating current (AC) voltages in excess of 30 volts root mean square (rms) or 50 volts direct current (DC) or any lower voltage that could cause injury.

E. Construction of the payload and electrical GSE shall assure that all conductive external parts and surfaces are at ground potential at all times.

F. Cables extending across work areas shall be protected against damage from personnel activity or equipment use.

G. Switches/controls which can create hazardous conditions if inadvertently operated shall be guarded, shielded, or otherwise protected against inadvertent switching.

H. Electrical fuse and switch boxes shall be labeled on the outside or inside cover to show the voltage present, rated fuse capacity, and equipment that the circuit controls.

I. Non-bypassable interlocks shall be used to prevent possible shock whenever a voltage in excess of 500 volts is exposed upon opening an access door, cover, or plate.

J. All GSE shall meet the requirements of the "National Electric Code (NEC), National Fire Protection Association 70 (NFPA 70)."

K. Dead-end wires shall be completely insulated.

L. Three-phase power sequencing must be verified in each KSC processing facility prior to connection.

M. Battery charging/conditioning shall be accomplished in the battery laboratories unless approval is granted from the LSSO to accomplish the charging elsewhere.

Battery charging equipment shall be continuously monitored by personnel. Charging/conditioning performed in hazardous locations shall comply with paragraphs 4.4.2.4.1 and 4.4.2.4.2. The payload organization should consider incorporating voltage and current

limiters, fuses, diodes, and temperature and pressure monitors in the charging/conditioning electrical GSE.

N. The payload should be assessed to determine if the loss of power during any phase of ground processing is a hazard to personnel or equipment. If so, an alternate or backup power source may be required.

4.3.2.2 Grounding, Bonding, and Shielding -

A. The design, construction, and installation of equipment shall be such that all external parts, surfaces, and shields are at ground potential at all times.

B. Grounding and bonding schemes shall ensure proper interfacing between equipment and facility.

C. Power cords on GSE shall provide a non-current carrying ground conductor unless the unit is double insulated.

D. Grounding/bonding connections of GSE shall be designed to minimize the possibility of inadvertent disconnection.

1) Solder shall not be used for external connections.

2) Threaded fasteners shall use lock washers.

E. GSE external bonding straps and jumpers shall be capable of carrying the maximum expected fault current.

F. Additional grounding requirements for ordnance and propellant operations are included in the applicable sections.

4.3.2.3 Electrical Maintenance Operations - Maintenance operations on energized electrical circuits are normally prohibited. Maintenance operations shall be performed in accordance with accepted industrial practice. In addition, the following shall be included:

A. Any accessible capacitor circuitry which presents a hazard to personnel shall be discharged prior to performing maintenance.

B. Protective equipment such as nonconducting fuse pullers, rubber gloves, nonconductive matting, etc., shall be used when working on energized circuits which could cause personal injury.

C. Procedures for tagging and lockout of control switches and circuit breakers shall be provided.

D. All grounds shall be verified to be intact.

E. Worn, abraded, or defective insulating material shall be repaired or replaced.

F. Only fuses of proper voltage and current ratings shall be used in circuits. No other material will be used in place of a fuse.

4.3.2.4 Electrical Control of Hazardous Functions - Where electrical GSE is used to control a potentially hazardous function, it shall be designed to be failure tolerant. Acceptable failure tolerance will be determined by the LSSO during the safety review process. Where feasible, failure tolerance shall be implemented through design control rather than procedural control. Design control can be implemented by eliminating the potential hazard (e.g., the current-limiting features in EED bridgewire checkers), providing a fail safe design (e.g., current-limiting fuses) or requiring multiple component failures and/or operator actions prior to a hazardous event occurring.

4.3.2.5 Energized Electrical Equipment -

A. Energized equipment will be manned or connected to the manned facility emergency power shut-off system. The electrical equipment will be powered down during non-working hours. All electrical equipment located outside of a hazardous processing area will be inhibited from supplying power to electrical equipment located within the hazardous processing area during non-working hours.

B. Electrical equipment that must remain energized for hazardous operations (i.e., maintaining spacecraft thruster solenoid valves in an opened or closed state) shall be equipped with an uninterrupted power source such as a battery backup.

4.3.2.6 Battery charging operations should occur in an approved charging facility. Battery charging requirements for batteries that cannot be removed from flight hardware will be assessed on a case-by-case basis.

4.3.3 Pressure/Vacuum Systems

Pressurized systems contain fluids above atmospheric pressure. Vacuum systems contain fluids below atmospheric pressure. Pressure system elements include tanks, accumulators, lines (e.g., piping, tubes, and hoses), fittings, gauges, filters, valves, regulators, and other components.

4.3.3.1 Pressure System Requirements -

4.3.3.1.1 Flight pressure systems shall meet the requirements of NSTS 1700.7, Chapter 2, Technical Requirements.

4.3.3.1.2 The following requirements shall be met by both flight and ground pressure systems:

A. To preclude personnel injury, provisions shall be made for accomplishing remotely controlled pressurization of the flight pressure system. Exception to this requirement is when the conditions of Paragraph 4.3.3.2.1 do not apply or when the payload operator provides a certification statement of system pressure testing to the LSSO in accordance with Paragraph 4.3.3.2.2. Normally, remote pressurization of GSE is not required.

B. Regulator failure shall not create a hazard to personnel or equipment during ground processing.

C. All items, including gauges, which come in contact with the service fluid shall be of compatible material. A list of compatible materials for hypergolic propellants and hydrogen systems is available from the KSC LSSO (ref. KSC Document 79K11948).

D. All pressure system connectors shall be selected to make it physically impossible to mix fluid media if a hazardous condition can be created by mixing two fluids. Example: Fuels and oxidizers or GN_2 and GHe in an LH_2 system.

4.3.3.1.3 GSE containing pressure systems shall meet the following requirements:

A. Pressure vessels used in GSE systems shall meet the design, test, labeling, marking (it is desired but not necessary to have the pressure vessel code stamped), and operating requirements as specified in "American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Codes," Section VIII, Unfired Pressure Vessels, Division I or Division II, as applicable. If the pressure test is based on a level less than the pressure vessel maximum allowable working pressure (MAWP), the vessel shall be derated to maximum operating pressure (MOP). Pressure vessels shall be registered with the National Board of Boiler and Pressure Vessel Inspectors, or the user must maintain the design drawings and design and stress calculations for the life of the vessel.

B. GSE pressure systems hardware other than pressure vessels shall be marked as follows:

1) Pressure system lines (where the function of the line is not immediately apparent) shall be labeled with the MOP, fluid content, and direction of flow. Labeling should be in accordance with KSC-STD-SF-0004, "Color-coding of Fluid Systems Piping."

2) If used, color-coding should comply with KSC-STD-SF-0004.

3) Other system components shall be labeled with their manufacturer's name and part number, serial number (if applicable), pressure rating, and direction of flow.

C. Pressure systems components (excluding pressure vessels) shall have a design burst pressure (D.B.) of at least 4 times the MOP of the system (low carbon stainless steels shall have a D.B. of 4.5 times MOP) and should conform to either MIL-STD-1522, "A Standard General Requirement for Safe Design and Operation of Pressurized Missile and Space Systems," or JSC SW-E-0002, "Space Shuttle Program GSE General Design Requirements." Components shall be pressure tested at 1.5 times MOP unless otherwise approved by the LSSO.

D. Regulators shall be selected so that their working pressure falls within the center 50% of their total pressure range if susceptible to inaccuracies or creep.

E. Flight and GSE components downstream of a GSE regulator shall be designed to safely operate under full upstream pressure. Open-ended purge systems may be protected by flow restriction orifice devices.

F. If the requirements of Paragraph E (above) cannot be met, relief devices shall be provided in accordance with ASME/ANSI codes, and a minimum shall be provided as follows:

1) Downstream of last GSE regulator prior to flight hardware interface.

2) GSE pressure vessels.

3) Downstream of regulators where upstream pressure exceeds downstream design operating pressure.

4) Container purge systems using metal tubing or flex hose.

5) Container purge systems using plastic tubing when the failure of the tube provides sufficient margin of safety to the downstream equipment.

6) All relief devices shall be relief valves when pressure exceeds 149 psig.

G. Set pressure: Pressure relief valves shall be set to relieve at a pressure not to exceed the MAWP of the vessel or the design pressure of the system involved (including flight systems), and the set limits shall be specified in the Operation and Maintenance Requirements Document (OMRSD) or other operating and maintenance documents. The setting of relief valves must always be sufficiently higher than the operating pressure to ensure that the valves

will reclose above the operating pressure. See ASME Code, Section VIII, Division 1, paragraph UG-134, and Appendix M, paragraph M-11, and ANSI/ASME B31.3, paragraph 322.6.3.

H. Required relieving capacity: For pressure vessels, the required relieving capacity shall be determined in accordance with the ASME Code, Section VIII, Division 1, paragraph UG-133, or Division 2, paragraph AR-150.

For piping/tubing systems, the required relieving capacity shall be equal to or greater than the maximum flow capability of the upstream regulator or pressure source and shall prevent the pressure from rising above the limits specified in ANSI B31.3 See ASME Code, Section VIII, Division 1, paragraph UG-133, and Division 2, paragraph AR-150, and ANSI/ASME B31.3, paragraphs 301.2 and 322.6.3.

I. Relief devices shall be located so that other components such as shut-off valves cannot render them inoperative. Relief devices and their associated discharge plumbing shall be adequately supported such that their discharge impulse will not cause structural failure.

J. Pressure relief for toxic liquids and/or vapors shall be designed and located so that gases and liquids or vapors will not enter any inhabited areas. Pressure relief for inert gases shall not be discharged into a confined, occupied area where oxygen content could be lowered below acceptable limits. Pressure reliefs for high pressure gases and liquids shall be located such that the discharge will not endanger personnel.

K. Pressure systems shall be equipped with gauges as follows:

1) Downstream of each regulator.

2) On any storage system.

3) On any section of the system where pressure trapped by isolation valves creates a hazard.

L. All pressure gauges shall comply with the following requirements:

1) Gauges shall be selected so that the operating pressure is not more than 75% of the highest graduation.

2) Pressure gauges shall be of one piece, solid front construction and shall have an optically clear shatterproof window. Gauges should be designed for bolted flush front panel mounting.

3) Gauges shall have blowout backs to allow unrestricted venting in the event the gauge sensing element ruptures.

4) All items which come in contact with the service fluid shall be constructed of compatible material. Use of material other than 316SS requires LSSO approval. Bourdon-tube bleed screws may be of any 300SS.

5) A due date calibration sticker shall be affixed to gauges used for safety-critical monitoring.

6) Gauges shall be equipped with a bourdon-tube bleeder or equivalent device to facilitate cleaning.

M. All GSE using flex hoses with pressures above 150 psig shall be designed to provide attachments for flex hose restraining devices.

N. Isolation valves shall be designed to permit flow or isolation in both directions at the valve's MAWP.

O. Pressure systems shall be designed so that pressure cannot be trapped in any part of the system without bleed capability.

P. Manually operated valves and regulators shall be selected so that over-torquing the valve stem or regulator adjustment cannot damage soft seats to the extent that seat failure occurs. Designs using uncontained seats are unacceptable.

Q. Pressure system elements which are not intended to be reversible shall be designed or marked such that they will not be connected in a reverse mode.

R. Lines, relief devices, and other pressure system elements shall be routed and/or located to provide for the protection of other systems and personnel.

S. Control stations shall have adequate instrumentation to allow personnel to monitor pressure levels and confirm that initiated actions have occurred.

T. Control stations shall be designed so that the operator does not have to leave the station to monitor hazard levels.

U. Systems shall have shut-off valves located as close to the supply vessel as practicable.

V. Check valves shall be provided where backflow of fluids would create a hazard.

4.3.3.1.4 Vacuum Systems - Relocated to Paragraph 4.3.3.3.

4.3.3.1.5 Flexible Hoses - Flexible hoses consist of an innerliner tube of teflon or other material (compatible with the service fluid) reinforced by layers of wire and/or fabric braid or wrap. Use of flex hoses should be minimized. Requirements for flexible hoses are as follows:

A. Connection, disconnection, installation, inspection, maintenance, and testing shall be accomplished in accordance with the manufacturer's specifications and recommendations unless otherwise specified in this document.

B. Flexible hoses shall be installed so that they do not carry any external mechanical load and are not subjected to tension, torsion, or overheating.

C. All flexible hoses shall have a design burst pressure equal to or greater than 4 times the MAWP.

D. All flexible hoses pressurized to 150.0 psig (10.34 bars) or greater shall be contained or restrained. Hose restraint shall be accomplished using a chain or cable securely anchored to a substantial object and to the hose assembly at the following points: 1) Hose end connector; 2) each union or hose splice; and 3) intervals not to exceed 6 feet (1.83 meters). Hose restraint devices and attachment methods shall be approved by the LSSO.

E. The payload organization shall establish criteria and obtain LSSO approval for periods of inspection and retest. Time in service, type of service, and pressure are factors for determining need of pressure test. LSSO approval shall be obtained prior to performing pressure testing at the launch site.

F. All flexible hoses shall be inspected prior to use. Flexible hoses which show signs of physical damage shall be replaced.

G. Flexible hose assemblies shall be pressure tested to 1.5 times their MAWP.

H. GSE flexible hoses shall be identified and marked. Each flexible hose assembly shall have a metal tag(s) attached which bears the following information:

1) Date of proof test (month and year).

2) Dedicated fluid service; e.g., fuels, oxidizers, hydraulics.

3) MAWP.

4) Identifier (manufacturer/part number).

J. After each pressure test recertification, the old tag(s) will be removed and new ones attached.

4.3.3.1.6 GSE Hydraulic Systems - GSE hydraulic systems shall comply with MIL-STD-1522 and the following requirements:

A. Hoses shall be in accordance with MIL-H-25579, "Hose Assembly, Tetrafluoroethylene, High Temperature, Medium Pressure," Class 1; MIL-H-38360, "Hose Assembly, Tetrafluoroethylene, High Temperature, High Pressure, 3000 psi, Hydraulic and Pneumatic"; or "Society of Automotive Engineers (SAE) Standards," and shall be suitably protected against chafing where necessary to prevent damage to the hose or adjoining structure, tubing, wiring, and other equipment. (Systems over 3,000 psi will be handled on a case-by-case basis.)

B. Only system compatible lubricants shall be used on threaded fluid line connections.

C. Pressurized reservoirs shall have the pressure controlled by a pressure regulator, and shall have an air-space relief valve to protect from excessive pressure.

D. Reservoirs shall be provided with a fluid level indicator.

E. The suction head of all pumps shall be maintained between the limits recommended by the pump manufacturer.

F. Pump pulsations shall not adversely affect system tubing, components, and supports and shall not cause damage or improper operation of the equipment on flight systems.

G. The system shall not cause damage to critical systems due to reduced flow, such as that caused by single pump operation of a multipump system, or increased flow, such as that caused by accumulator operations.

4.3.3.2 Pressure System Operations - Pressure system operations shall comply with the following:

4.3.3.2.1 The following flight and ground support system pressurization operations shall be accomplished remotely (e.g., locate control station behind a blast shield) unless otherwise approved by the LSSO:

A. The first time a flight system is pressurized above 25% of the design burst at the launch site. This pressure is designated the "initial pressurization level."

B. Any flight system pressurization above the initial pressurization level; this latter pressurization becomes the new initial pressurization level.

C. Any pressurization above MOP/MAWP.

D. Any pressurization of a system that has suspect integrity.

4.3.3.2.2 Remote pressurization may not be required if the payload organization provides documentation which certifies the following:

A. The assembled system has been pressure tested at a pressure which is at least 1.5 times the system MOP unless otherwise approved by the LSSO. Flight systems may be pressure tested at the component level if welds will be x-rayed after assembly.

B. The assembled system has been functionally leak tested at a pressure equal to or greater than MOP. The system log book shall track system handling/movement in addition to pressurizations, maintenance, etc.

C. System configuration has not been modified or repaired subsequent to the above testing. Unwelded relief or sensing devices may be replaced after system pressure testing but not after system leak testing, in accordance with Paragraph 4.3.3.2.9.

D. A procedure has been written which requires inspection of the system upon arrival at the launch site for damage sustained during transportation and handling. The procedure shall also require a check of the pressure system log book to verify that activity after the pressure test and leak test did not affect the integrity of the system. Provide procedure name and number, step numbers and test which require the inspection, and any additional inspection criteria.

4.3.3.2.3 Personnel will be allowed in the immediate proximity of pressure systems only when pressure does not exceed the system MOP.

4.3.3.2.4 System integrity shall not be broken on pressurized systems without first depressurizing to 10 psig or less. Depressurization shall be accomplished only using components designed for the purpose. Backing off of line fittings, when pressures exceed 10 psig, to depressurize is permitted if the trapped volume does not exceed 1.5 cubic inches. Tightening of line fittings under pressure is also prohibited.

4.3.3.2.5 Systems shall not be pressurized or depressurized at rates which present unsafe situations, such as heat rise to autoignition. These rates shall be identified in the applicable operating procedure.

4.3.3.2.6 Pressure system bolts and fittings shall not be torqued while the component is under pressure.

4.3.3.2.7 Relief valves shall be inspected, reset, tested, and labeled annually.

4.3.3.2.8 Pressure gauges shall be inspected and calibrated annually and a due date label applied where used in safety critical systems.

4.3.3.2.9 All nonhydraulic pressure systems are to be leak tested with an inert medium at MOP at the launch site prior to using propellants or hazardous gases. Any time a component is modified, repaired, or replaced, it shall be pressure tested to 1.5 times MOP at the component level. If the component is welded into the system, the welds shall also be pressure tested at 1.5 times MOP. The reassembled system shall again be leak tested at MOP using an inert medium.

4.3.3.3 Vacuum Systems and Requirements - Negative pressure protection shall be provided for systems not designed to withstand pressure below 1 atmosphere. This can be accomplished by the use of check valves or ambient automatic pressure valves. Vacuum systems should be designed to T.O. 00-25-223, "Integrated Pressure Systems and Components (Portable and Installed)."

4.3.4 Radiation

Sources of ionizing and nonionizing radiation must be adequately controlled during all phases of ground, launch, and postlaunch operations to assure the protection of personnel, facilities, and equipment, and the compliance with applicable federal, state, and NASA/DOD regulations and requirements. Such sources include radioactive materials, radiation-producing equipment (e.g., x-ray devices, particle accelerators, radio frequency/microwave emitters, etc.), lasers, and optical emitters (e.g., ultraviolet, infrared, and high intensity visible light sources). Specific requirements are provided in detail in the referenced applicable control documents and must be coordinated through the LSSO. All payload organizations are responsible for compliance with the applicable launch site requirements.

4.3.4.1 Radiological Health -

A. Applicable radiological health program documents governing uses of ionizing and nonionizing radiation sources at ELS include:

KHB 1860.1A, "KSC Ionizing Radiation Protection Program"

KHB 1860.1A, Appendix D, "Radiological Controls for Major Radiological Sources (MRS) and Nuclear Assemblies"

KHB 1860.2, "KSC Non-Ionizing Radiation Protection Program"

AFR 122-15, "Nuclear Power System Safety Reviews and Surveys"

AFR 122-16, "Nuclear Safety Review Procedures for Space or Missile Use of Minor Radioactive Sources"

AFR 161-16, "Radioactive Material Licenses and Permits"

45 SPW S-PLAN 28-74, "Major Radiological Source Support (Hot Shot)"

45 SPWR 160-1, "Radiation Control Program"

AFOSH STD 161-9, "Exposure to Radiofrequency Radiation"

AFOSH STD 161-10, "Health Hazards Control for Laser Radiation"

The above-mentioned documents contain procedural/ administrative requirements for radiation source approvals and usage.

B. All uses of radiation sources require review and evaluation for approval by the appropriate launch site Radiation Protection Officer (RPO). Radioactive materials procurement, use, storage, and transportation at launch/landing sites are subject to specific requirements. Such activities must be coordinated with the launch/landing site RPO at least 60 days in advance of arrival to the launch site to assure compliance with applicable regulations. Identification of the launch/landing site RPO will be provided through the LSSO.

C. General radiological health requirements include, but are not limited to, the following items:

1) Radiation sources and associated equipment will be designed, constructed, installed, and utilized so as to assure that personnel exposures and the potential for releases are kept as low as practicable and below applicable regulatory limits.

2) Flight radioactive sources should be installed as late in the countdown as practical.

3) Radiation sources shall be handled/operated utilizing only approved personnel, procedures, and equipment.

4) Inactive, unattended, or stored radiation sources shall be secured against unauthorized access or operation at all times.

5) Appropriate personnel access controls shall be established in all areas where radiation sources are used, operated, or installed.

6) Personal protective equipment and/or dosimetry shall be approved or utilized as assigned.

D. Radiation exposures shall be as low as reasonably achievable but shall not exceed the limits established in the above referenced documents.

E. Major Radiological Sources (MRS's) such as radioisotope thermoelectric generators (RTG's), radioisotope heater units (RHU's), nuclear reactors/assemblies, accel-erators, etc., must comply with additional controls and requirements as provided in the applicable program documents. Generally, radiation sources equal to/ greater than 1 curie, or capable of generating radiation levels equal to/greater than 1 rem/hour, are considered to be MRS's. Specific requirements for MRS activities include, but are not limited to, the following:

1) The payload organization shall provide a detailed description of the launch/landing site processing flow not later than 6 months prior to initial arrival of an MRS at the launch site. The description shall include identification of activities directly associated with MRS's, other activities occurring in the presence of MRS's, and any GSE associated with such activities. The detailed processing flow shall be developed incorporating the following requirements:

a. The number and duration of MRS processing activities and associated personnel proximity to an MRS shall be minimized. Payload and launch vehicle activities involving personnel proximity to an MRS shall also be minimized.

b. The number of facilities utilized in MRS processing activities shall be minimized. Such facilities shall be utilized on a sole-use or noninterference basis.

c. Each processing activity shall be assessed on the basis of personnel exposure incurred versus mission benefit achieved by the activity.

d. MRS installation for flight shall be made as late as operationally feasible.

e. The payload organization shall provide for and utilize nonradioactive/passive high fidelity MRS models whenever feasible.

2) The payload organization shall provide a detailed baseline dose projection for payload organization personnel involved in launch/landing site MRS activities. This baseline must be provided no later than 6 months prior to initial arrival of an MRS at the launch site.

3) A description of proposed changes to the MRS processing flow (including GSE and operations) with supporting rationale must be submitted by the payload organization prior to implementation. The rationale shall include the reason for the change and an assessment of its impact on the safety analysis, the baseline dose projection, other processing activities, procedures, hardware, etc.

4) Payload organization activities involving radiological contingency planning and nuclear safety analyses shall be coordinated with the launch site RPO.

5) The payload organization must obtain final approval of their MRS radiation use authorization request from the launch site RPO not later than 6 months prior to launch or 90 days prior to MRS arrival at the launch site, whichever is earliest. Final approval is contingent upon closure of all open items by the payload organization to the satisfaction of the launch site RPO.

F. General requirements for GSE utilizing radioactive gases are as follows:

1) The payload organization shall document the design and maintain records of maintenance, checkout, and use of GSE systems utilizing radioactive gases at the launch sites. Such records shall be available to the LSSO and the launch site RPO.

2) Planned releases and the potential for accidental releases of radioactive gases shall be minimized. The launch site RPO may require recapture of radioactive gases prior to venting of residual quantities.

3) Vent outlets shall be placed at heights or locations inaccessible to personnel. The vents shall be located to prevent reentry of exhaust into habitable areas and shall be conspicuously identified.

4) Venting of radioactive gases will require favorable meteorological conditions and launch site RPO concurrence.

5) Operations involving flow of radioactive gases will not occur during normal working hours unless specifically authorized by the launch site RPO.

4.3.4.2 Radiation Safety - Additional radiation hazard controls required by the LSSO are provided below:

A. Radiation sources associated with payloads must be compatible with and have no adverse safety effects on ordnance items, propellants, high pressure systems, critical structure components, or systems of any other payload, the Space Shuttle, or its crew.

B. RTG's and other major radiological sources shall be provided with redundant ground cooling systems, if cooling is required to maintain safety, to assure adequate heat dissipation during prelaunch and postflight operations. Disposal of this coolant shall be coordinated with the appropriate Biomedical Office.

C. Radiation source shields, interlocks, fail-safe systems, and limit switches shall be checked for proper operation.

D. All radiating systems shall be designed, constructed, and operated to prevent exposure of personnel, facilities, and equipment to extreme temperatures, high voltages, toxic fumes and gases, and unnecessary radiant energy.

4.3.4.3 Optical Systems - The potential hazards which must be considered in the design, handling, and operation of optical equipment and associated energy sources may be grouped into five categories as follows:

A. Hazardous optical radiation to include ultraviolet, infrared, and visible radiation.

B. Temperature extremes.

C. Shatterable materials.

D. Contamination from gases and cryogenics.

E. High voltage and x-rays.

4.3.4.3.1 General Optical Requirements - The following requirements shall apply to both flight and ground optical systems:

A. Optical instruments shall be designed such that harmful light intensities and wavelengths cannot be viewed by operating personnel.

B. Quartz windows, apertures, or beam stops and enclosures shall be used for hazardous wavelengths and intensities unless other suitable protective measures are taken to protect personnel from ultraviolet and/or infrared burns or x-ray radiation.

C. Light intensities and spectral wavelengths at the eye piece of direct-viewing optical systems shall be limited to levels below the maximum permissible exposure (MPE).

4.3.4.3.2 Laser System Requirements - In addition to the referenced documents, the following requirements shall apply to both flight and ground hazardous laser systems:

A. Limit stops, interlocks, and shields shall be provided to ensure that a laser beam cannot be misdirected.

B. Laser power shall be locked out during all operations except laser testing.

C. Positive locking features shall be provided to preclude focus and/or directional changes due to vibrations or inadvertent contact by operating personnel.

D. Laser systems shall be designed so that all external components are at ground potential at all times.

E. Materials used must be able to withstand the stresses caused by repetitive laser pulsing for the duration of checkout and mission performance.

F. Laser systems shall incorporate a shutter system, beam stop, or attenuator capable of preventing output emissions in excess of the appropriate MPE level when the laser or laser system is on standby.

G. Provisions shall be made to measure power output and perform boresighting with the beam totally enclosed and without unnecessary exposure to operating personnel.

H. Laser target materials shall be nonreflective and fire resistant and shall not emit toxic contaminants.

I. Laser installations shall incorporate adequate means to prevent the accumulation of hazardous cooling fluids and their by-products.

J. Whenever toxic chemicals and/or cryogenic materials are utilized with laser systems, shut-off valves shall be provided to control leakage in the event of a line rupture.

4.3.4.3.3 Laser Operations - Laser operations shall include but not be limited to the following requirements:

A. Alignment of target, optics, filters, etc., shall be accomplished utilizing low-powered visible lasers.

B. Active beam or target viewing shall be done only by closed circuit television or an optical comparator with an appropriate filter.

C. Laser beams shall not be directed toward flammable or explosive materials.

D. Activated lasers shall not be left unattended.

E. Personnel whose occupation or assignment may involve exposure to laser radiation shall use laser safety goggles approved by the Biomedical Office. These goggles shall protect for the specific wavelength of the laser and be of optical density adequate for the energy levels involved.

4.3.5 Ordnance

4.3.5.1 Electroexplosive Device (EED) Categories - EED's are categorized at ELS based on the effects of inadvertent initiation. EED classifications are as follows:

Category A: Category A electroexplosive devices are those which, by the expenditure of their own energy, or because they initiate a chain of events, may cause injury or death to people or damage to property.

Category B: Category B electroexplosive devices are those which will not, in themselves, or by initiating a chain of events, cause injury to people or damage to property.

A device shall be assigned Category A prior to installation whenever test data to the contrary is not available. A device assigned Category A prior to installation may be downgraded to Category B after installation if the effects of the device and the subsequent chain of events are controlled to the satisfaction of the LSSO. Conversely, a device assigned Category B prior to installation may require upgrading to Category A after installation. The payload organization shall categorize all EED's for both the pre- and post-installation situations and be able to provide the LSSO with supporting data for each categorization.

4.3.5.2 General Ordnance Requirements - All ordnance systems shall comply with the requirements of NSTS 1700.7 and the following:

A. All ordnance and solid propellant motors shall be handled and stored in accordance with the requirements of their hazard classification and storage compatibility grouping. Items which have not previously been classified shall be tested in accordance with T.O. 11A-1-47, "Explosives Hazards Classification Procedures," and classified accordingly. AFR 127-100, "Explosive Safety Standards," will be used for guidance for storage, handling, and transportation of ordnance and propellants. See Appendix D for ordnance storage and handling data requirements.

B. All Category A ordnance circuits must be capable of being physically disconnected between the ordnance device and the power source as close to the ordnance item as possible.

C. Category A ordnance and associated circuitry shall be accessible in the Orbiter to facilitate electrical checkout and connection as late as possible prior to launch.

D. All ordnance device installations at the launch site shall be in an ordnance sited or licensed facility.

E. For Category A EED's, electrical connections shall be made in the Orbiter unless otherwise approved by the LSSO.

F. Prior to electrical connection of Category A EED's, a DC power-on and power-off no-voltage check shall be made. The power-off no-voltage check shall be performed immediately before the connection.

G. Receipt of installed or early installation and connection of Category B EED's may be accomplished with the LSSO approval, provided the connection of these devices does not restrict interface verification tasks.

4.3.5.3 Safe and Arm (S&A) Devices -

A. Transition from the SAFE to the ARM position shall require 90 degrees of rotation of the mechanical barrier.

B. The S&A device shall not be capable of propagating the ordnance train with the barrier rotated less than 50 degrees from the SAFE position.

C. The visual and remote SAFE position shall not be indicated unless the device is less than 10 degrees from the normal SAFE position.

D. Firing circuits of S&A devices shall be electrically connected after payload installation in the Orbiter. S&A devices without a direct interface with the Orbiter may be electrically connected after final ordnance electrical system checks and power is removed from the system. The S&A safing pin shall remain installed until final closeout of the payload bay.

E. S&A Rotation Tests: Rotation of S&A devices during ground test and processing shall be done with the explosive transfer assembly (ETA) disconnected from the S&A or at the point of ETA terminus. All rotation tests of S&A's shall be completed before firing circuits are electrically connected. If the firing cir cuits must be connected during a rotation test, a safety assessment shall be provided to show that inadvertent ignition of the detonators will not cause a hazardous condition. All rotations require LSSO approval.

4.3.5.4 Ordnance Operations -

A. Ordnance shall be processed only in those areas approved by the LSSO. Solid/liquid propellants designated for one payload shall not share an operating location with items designated for another payload except for payload integration activities.

B. Test equipment used to check component and circuit operation must be of a type that limits energy input and must be approved by the LSSO. See Paragraph 4.3.5.6 for additional requirements.

C. Electrical continuity and resistance checks of ordnance circuitry shall be performed using only in-calibration test equipment approved by the LSSO.

D. All ordnance deliveries to the launch site shall be coordinated with the LSSO.

E. All ordnance deliveries from storage to the payload organization shall be coordinated with the LSSR.

F. Electromagnetic interference (EMI) testing shall not be conducted with live EED's installed without approval of the LSSO.

G. Materials susceptible to the generation, collection, and holding of static electrical charges shall be selected from the LSSO-approved list.

H. Disposal of surplus or defective ordnance items shall be coordinated by the LSSO. Disposition shall be determined jointly by the LSSO and the payload organization.

I. Based upon the radio frequency (RF) and EED susceptibility, installation, removal, and electrical connection/disconnection may require RF silence. Local RF silence and no-switching periods are required. The periods of RF silence shall be requested by the payload organization and shall be identified by an LSSO-approved TOP.

J. Grounding/bonding is required to ensure that electro-static charges cannot build up to levels which can cause ignition of ordnance items.

K. EED faraday caps are required during storage, handling, and after mechanical installation. They shall not be removed until electrical connections are to be made.

L. All personnel within the hazard control area during ordnance operations shall wear nonstatic-producing, flame-retardant coveralls. Persons performing the work shall wear approved grounding devices.

4.3.5.5 Ordnance Marking -

A. Live ordnance and associated flight items (e.g., arm plugs) shall be the natural body color of the device.

B. Nonflight items shall be color-coded, and this color-coding shall be submitted to the LSSO as part of the ground safety data package.

4.3.5.6 Ordnance Test Equipment - Requests for approval for use of ordnance electrical test equipment used for testing explosive ordnance items or circuits connected to these items prior to or after installation shall be submitted to the LSSO. The payload organization shall provide the model number, engineering drawings and specifications, and the system safety analysis of the test equipment. Approval by the LSSO shall be by manufacturer model number and requires a valid calibration seal for use at the launch site.

A. EED Bridgewire Resistance Measurement Meters–

1) The meter shall be designed such that maximum available applied current does not exceed 10% of the no-fire current of the EED or 50 mA, whichever is less. It shall also be designed so that in a worst case (multiple) failure condition, the available applied current cannot exceed the no-fire current of the EED.

2) The optimum resistor location is adjacent to the output leads and inaccessible. Other locations are also acceptable, if it can be shown that by-passing the resistor is not credible. (Current-limiting resistors in the test leads, to meet the above requirements, are unacceptable.)

3) Meter leads shall be shielded and connector shell-to-shell contact shall precede pin-to-pin contact.

4) Calibration shall be at least annually. Calibration procedures shall verify the safe configuration; e.g., the proper voltage battery with the encapsulated current-limiting resistor installed.

B. No-Voltage Meters. No-voltage meters shall be designed to detect one-tenth of the no-fire level of the EED or 50 mV, whichever is less, at a pulse width of 1 millisecond. The use of computerized no-voltage meters is acceptable if proper current-limiting can be demonstrated.

4.3.6 Mechanical, Electromechanical Devices

Mechanical or electromechanical devices that are used for such purposes as structure deployment or actuating release mechanisms must be evaluated to establish whether in the event of inadvertent activation damage to equipment or injury to personnel could occur. If it is determined that inadvertent activation is either critical or catastrophic, then the device must be failure tolerant in accordance with Paragraph 4.1.1. These devices shall be identified in the operational hazards analysis with the requirement for caution and warning notations incorporated in the TOP's (See 3.3.2).

4.3.7 Propellants

The design considerations contained in Air Force Systems Command Design Handbook, AFSC DH 1-6, "System Safety," Chapter 3, Section 3e, and Chapter 4, Section 4b, are a useful guide and should be used in conjunction with the requirements of NSTS 1700.7 for designing payload liquid/gas propellant systems. If the following minimum requirements cannot be met, consideration will be given on an individual basis to other design techniques.

4.3.7.1 Propellant System Requirements -

A. Materials selected for use in propellant systems shall be compatible with propellants used. This should include compatibility under operating pressure, shock, vibration, and temperature loadings and include analysis of items such as stress corrosion. Refer to either Air Force Manual, AFM 161-30, "Chemical Rocket/Propellant Hazards," Volume II, or John Hopkins University, "Chemical Propulsion Information Agency (CPIA) Publication Number 394, Chemical Rocket/ Propellant Hazards," Volume III, for specific propellant properties.

B. Propellants shall be separated so that malfunction of either the oxidizer or fuel subsystems cannot cause mixing.

C. Incompatible system connections shall be keyed or sized so that it is physically impossible to interconnect them.

D. For systems requiring nonmetallic materials, materials selected shall not result in hazardous reactions.

E. For systems requiring insulation or acoustic damping, nonabsorbent, nonflammable materials shall be used in compartments or spaces where fluids and/or vapors could invade the area.

4.3.7.2 Propellant Systems GSE Requirements -

A. A positive means of shutting off propellant flow from tanks shall be provided and shall be readily accessible.

B. The actuator for remotely controlled valves shall be capable of opening and closing the valve under design flow and pressure. Throttle capability shall be considered in the selection of remotely controlled valves. Ball and gate valves should not be used.

C. Remotely controlled valves shall provide for remote monitoring of open and closed positions.

D. Normally open or closed valves shall have a spring on the actuator capable of operating the valve to the fail-safe position without an external actuating force under system operating conditions.

E. Manually operated valves shall be capable of being opened or closed under full system pressure.

F. Balanced manual valves that utilize external balancing ports or vents open to the atmosphere shall not be used.

G. The payload organization shall describe their plans for controlling a propellant leak throughout the ground processing timeline up to, and including, installation into the Orbiter payload bay.

H. Provisions shall be made so that propellants cannot be trapped in any part of the system without provisions for draining.

I. Hypergol equipment (i.e., valves, quick disconnects) must be designed to be compatible with and operated by personnel wearing PHE gloves.

J. Hazardous fluid vent system requirements are as follows:

1) Pressure relief vents for hazardous fluids shall be designed and located so that vapors will not enter any inhabited areas.

2) Venting of toxic fluids shall be through a scrubber or neutralizing agent or by similar methods which would prevent unauthorized release.

3) Each line venting into a multiple use vent system shall be protected against back pressurization by means of a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

4) Incompatible fluids shall not be discharged into the same vent or drain system.

5) Fuel or toxic fluid vent systems shall be equipped with a means of purging the system with an inert gas to prevent explosive mixtures and/or to maintain system cleanliness.

6) Vents shall be placed in a location normally inaccessible to personnel and at a height or location where venting will not normally be deposited into habitable spaces. Each vent shall be conspicuously identified using appropriate warning signs, labels, and markings approved by the LSSO.

7) Vent systems shall be sized to provide minimum back pressures consistent with required venting flow rates. In no case shall back pressures interfere with proper operation of relief devices.

K. Serviceable hypergolic components, such as quick disconnects, filters, hoses, valves, etc., shall be permanently marked by electroetch, metal impression stamp, or other permanent method to indicate the specific hypergolic fluid to which the component will be exposed.

L. Items used in any fuel or oxidizer system shall not be interchanged after exposure to the respective media.

M. Lubricants for hypergolic systems shall be restricted to Krytox 240AC or equivalent. Use of a lubricant other than Krytox 240AC shall be approved by the LSSO.

N. Hypergolic propellant pumps shall be specifically designed for the particular hypergolic fluid.

O. All components, including flow meters, used in hypergolic propellant systems shall be designed and qualified for hypergolic applications.

P. Flanged connections shall utilize the following types of flanges: slip-on, weldneck, lapped joint, or blind. Bonding straps shall be used across flanged connections.

Q. Materials used in contact with fuels, oxidizers, or combustible gases shall be selected, tested, and certified in accordance with the requirements of NHB 8060.1, "Flammability, Odor and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion."

R. All controls and adjustments shall be identified by component number, system function, and direction of operation. The direction of fluid flow shall be clearly indicated with permanent markings on the exterior of each component.

S. All calibration adjustments, locked or unlocked, shall be designed so that the setting, position, or adjustment cannot be altered when the equipment is subjected to the service condition.

T. Sight glasses used for liquid level indicators shall be protected from physical damage.

U. The payload organization shall maintain records of the design, maintenance, checkout, and usage of GSE systems used at the launch sites. These records shall be available to the LSSO.

V. Check valves (one-way flow) shall be provided whenever a hazardous/contaminated substance can backflow into another system.

W. Liquid shall not be able to be trapped between valves if changes in ambient temperature can result in pressure rises above 110% of MOP. If the potential for this condition exists, automatic relieving is required.

4.3.7.3 Propellant Systems Operations -

A. New, modified, and/or repaired propellant storage or transfer systems must be validated by functional test prior to being certified for operational use. The following shall also be required as part of the certification procedure:

1) A leak test at MOP with an inert gas shall be performed.

2) Pressure control units shall be verified by use of certified, calibrated gauges.

3) Emergency shutdown systems and procedures shall be demonstrated using a referee fluid.

4) Proper operation of quick disconnects shall be demonstrated.

B. Simultaneous operations with hypergolic propellants is prohibited.

C. The payload and the propellant loading system must be commonly grounded and bonded during propellant transfer operations.

D. Prior to opening a toxic propellant system, it must be drained and flushed or purged to concentration levels approved by the LSSO.

E. Prior to replacement or storage of components or system repair, hypergolic or toxic system components shall be flushed and purged of all residual elements and appropriately capped or bagged and labeled prior to movement.

F. Disposal of propellants shall be coordinated with the LSSO.

G. Venting of toxic vapors to atmosphere shall only be done with LSSO approval.

H. Procedures shall contain emergency instructions developed by the payload organization to handle leaks and spills. These procedures shall be consistent with either AFM 161-30, Volume II, or CPIA #194, Volume III.

I. Propellant transfers shall be performed only in areas and at times approved by the LSSO. Personnel shall be limited to those needed in direct support of these operations.

J. Personal protective equipment which provides full respiratory protection and body coverage shall be worn during any dynamic payload and/or GSE toxic propellant transfer operations, or whenever the toxic propellants are not in a sealed system. At all other times that toxic propellants are present, emergency escape breathing devices shall be available for all personnel. Full respiratory protection and body coverage is mandatory for the following:

1) Any connection/disconnection of a propellant transfer system if it contains toxic propellants.

2) Any connection/disconnection of a propellant transfer system that had contained toxic propellants and concentration levels have not been verified to be below safe concentration levels.

3) All toxic propellant sampling operations.

4) Any servicing/deservicing/internal circulation (dynamic flow) of toxic propellants until system integrity has been verified; i.e., no leakage is present.

5) Any application of pressure to the toxic propellant transfer system until a stabilization period of 15 minutes minimum has been achieved and system integrity has been verified.

K. Downgrading from air supplied respiratory and full body coverage in item J above requires the LSSR's concurrence.

L. All personal protective equipment shall be compatible with the toxic propellants involved, and their use shall be approved by the LSSO and the appropriate Bioenvironmental Engineering/Biomedical Office.

M. Toxic vapor monitoring is required during break-in to any propellant system which has been contaminated by propellants and during the handling of contaminated parts. Toxic vapor monitoring is also required at the conclusion of any hazardous operation listed in Item J of this Section prior to opening of the control area to unprotected personnel.

4.3.8 Cryogenics

All cryogenic systems shall comply with the requirements of Paragraph 4.3.7, Propellants, and the following requirements.

4.3.8.1 Cryogenic Systems Requirements -

A. Source flow shall have throttling capability.

B. Pressure containing components within hydrogen systems shall be selected for minimum hydrogen blistering or hydrogen embrittlement susceptibility (reference NHB 8060.1).

C. GSE cryogenic valves with extended stems shall be installed with the actuator approximately vertical above the valve.

D. Joints in piping systems shall be of either butt-welded, flanged, bayonet, or hub type.

E. Cryogenic systems shall provide for thermal expansion and contraction without imposing excessive loads on the system. Bellows, reactive thrust bellows, or other suitable load relieving flexible joints may be used.

F. GSE vacuum-jacketed systems shall be capable of having the vacuum verified.

G. Cryogenic systems shall be designed so that anywhere a cryogen can be trapped between any valves in the system, automatic relief is incorporated to preclude excess pressure caused by conversion from liquid to gaseous state causing a rupture.

H. Cryogenic systems shall be insulated with an oxygen compatible material or be vacuum-jacketed to preclude liquefaction of air.

4.3.8.2 Cryogenic Systems Operations -

A. Cryogenic systems must be pressure tested with an inert medium at cryogenic temperature followed by a proof test at ambient temperature (no less than 60^{o}F). Pressure testing shall be 1.5 times MOP except where lesser factors (no less than 1.1 times MOP) are warranted to avoid adverse effects (e.g., plastic deformation or strain hardening) on the system.

B. Cryogenic systems, including vacuum-jacketed pipe, shall be cold-shock tested with an appropriate cryogenic inert medium (at MOP or greater) prior to introducing any hazardous commodity into the system. For liquid hydrogen systems, a mass spectrometer leak test with liquid helium is required. Cold-shock leak testing can be accomplished at proof pressure to satisfy the cryogenic proof requirements in Paragraph A.

C. Simultaneous loading of fuels and oxidizers must be approved by the LSSO.

D. All personnel involved in cryogenic propellant transfer operations, repairs, or adjustments to the system must wear LSSO and Biomedical Office approved personal protective equipment.

E. Flammable cryogenic systems shall be capable of being connected to an external vent system.

4.3.9 GSE Materials

A. A list of materials shall be maintained for each piece of GSE which interfaces with hazardous fluids. Hazardous fluids include, but are not limited to, gaseous oxygen, liquid oxygen,

gaseous hydrogen, liquid hydrogen, hydrazine, nitrogen tetroxide, monomethyl-hydrazine, Freon-21, ammonia, and potassium hydroxide. This list will be of sufficient detail to permit an evaluation of the compatibility of the GSE design with the environment in which it is to be used.

B. Mercury in liquid or vapor form shall not be used in GSE if a substitute of equivalent performance exists or an appropriate alternate design or method can be used. Mercury shall not be used in any applications where contamination of flight hardware or exposure to personnel could result.

C. Cleaning solvents and adhesive materials shall be contained in NFPA-approved safety containers. The use of and quantity allowed in the payload processing work area shall be approved by the LSSO. All users of these materials must comply with local fire, safety, and health regulations. Except where approved by the LSSO, the use of glass containers is prohibited in all payload processing work areas.

D. Use of flammable materials and static-producing materials shall be kept to a minimum in all payload processing areas. If any plastic film is to be used, the material shall be selected from the LSSO approved plastics list. The material, quantity, and location of use shall be included in the payload organization safety data package and approved by the LSSO. If a plastic film is not on the approved list, a sample (minimum 1 square yard) shall be submitted to the LSSO for test/evaluation and approval.

E. GSE that contains components made of shatterable materials which is to be used inside the Orbiter or in areas where it could fall into the Orbiter shall be designed to provide positive containment to prevent fragments from entering the Orbiter.

F. GSE designed for use directly in the Orbiter crew cabin or payload bay must meet the same materials flammability requirements as the payload/experiment itself. For these requirements see NSTS 1700.7, Paragraph 209, Subparagraphs 2 and 3.

G. GSE used in flight vehicle habitable areas or in the payload bay shall not be painted or coated with materials subject to chipping, flaking, or scaling.

H. Materials should be selected which are not nutrients for biological agents such as mold, mildew, fungus, etc. Experiments in habitable areas should not provide a source of contamination. Materials which are nutrients should be hermetically sealed or treated to render the exposed surfaces resistant to biological attack.

4.3.10 Industrial Hygiene

Hazardous materials and physical agents must be controlled during all phases of launch/landing site operations to protect personnel by preventing exposures in excess of applicable limits and to comply with applicable federal and state regulations and requirements.

A. Descriptive information concerning proposed uses of hazardous materials and physical agents will be provided by the payload organization to the LSSO for review and evaluation by the Biomedical Office.

B. General Industrial Hygiene requirements include, but are not limited to, the following:

1) Equipment which contains, possesses, or emits hazardous materials and/or physical agents will be designed, constructed, installed, and operated in a manner to ensure that the potential for exposure is kept as low as feasible.

2) The payload organization shall provide a list of all hazardous materials and physical agents containing names, quantities, locations, and proposed uses (reference Paragraph 3.2.I). The payload organization shall also submit to the LSSO one copy of the MSDS for each of these materials upon or before arrival at the ELS. MSDS's must also be submitted if at any time additional materials (not previously identified) are introduced onto the ELS.

3) Hazardous materials and physical agents shall be used only by properly trained personnel and in accordance with procedures reviewed by the Biomedical Office and approved by the LSSO.

4) Engineering or administrative controls shall be the primary means for preventing personnel exposures. When such controls are not feasible or
adequate to control exposure, personal protective equipment will be required. Personal protective equipment shall be approved by the Biomedical Office.

5) Planned releases of hazardous materials shall not be permitted without review and approval by the LSSO and the Biomedical Office. Supportive data shall be provided by the payload organization to identify maximum expected quantities and concentrations of planned releases.

6) All activities involving hazardous materials or physical agents are subject to monitoring by the Biomedical Office.

C. Specific Industrial Hygiene requirements are contained in the following documents:

1) KHB 1840.1, "Industrial Hygiene Handbook"

2) NMI 1800.3, "NASA Environmental Health Program"

3) KMI 1800.1, "Environmental Health Program"

4) KMI 1800.2, "Chemical Hazard Communication"

5) 29 CFR 1910, "Occupational Safety and Health Administration; General Industrial Standards"

6) AFOSH 161-8, "Permissible Exposure Limits for Chemical Substances"

7) "American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes"

4.3.11 Oxygen

The use of gaseous or cryogenic oxygen involves unique design requirements with respect to materials compatibility. Prior to commencement of design, the payload organization shall contact the LSSO to identify specific safety/compatibility requirements to be incorporated in design. Specific KSC documents providing results of compatibility testing are 79K09560 for liquid oxygen testing and 79K09561 for gaseous oxygen testing.

4.4 ENVIRONMENTAL

4.4.1 Meteorological Requirements

4.4.1.1 Propellants - Meteorological conditions established herein shall be observed by all agencies in scheduling and conducting transfer, handling, and use of toxic propellants.

A. Propellant operations shall not commence when the potential for passage of an electrical storm is within 5 miles. Propellant operations during storm passage shall be interrupted or expeditiously concluded at the discretion of the LSSR or supervisor in charge of the operation.

B. The supervisor responsible for the transfer/handling operations is responsible for obtaining the prevailing meteorological conditions, determining that the conditions meet those specified herein, and obtaining LSSR approval to proceed.

C. In order to protect personnel not involved in toxic propellant operations and the public domain, downwind concentrations of toxic propellant materials shall be controlled by limiting operations to certain meteorological conditions. Concentrations of toxic propellants shall

be kept at or below Biomedical Office approved safe levels at the launch site boundaries in the public domain and in the launch site industrial areas.

D. Personnel shall be evacuated or provided with emergency escape breathing devices and communications equipment in areas potentially at risk from toxic propellant operations as determined by the LSSO.

E. Evacuation of personnel shall be used in those situations where the potential for injury/illness is present.

F. Local propellant operations shall require protection in the immediate downwind sector.

4.4.1.2 Ordnance - Ordnance items shall not be transported, handled, installed/removed, or electrically connected/dis-connected when the passage of an electrical storm is within 5 miles. Ordnance operations shall be interrupted or safed during storm passage.

4.4.2 Hazardous Atmosphere

4.4.2.1 General - Hazardous atmospheres are defined as follows:

A. Flammable/Explosive Atmospheres - Hazardous atmospheres are defined as follows: A percentage of the lower explosive limit (LEL) shall be established to define a hazardous atmosphere for flammable/explosive gases or vapors by the LSSO on a case-by-case basis. Factors such as commodity involved, quantity, confinement area, the presence of oxygen-enriched atmospheres (greater than 25%), credible time for a hazardous condition to develop, and response time to complete emergency actions must be considered in establishing the percentage of the LEL. This percentage is usually 25% of the commodity LEL.

B. Oxygen Deficient Atmospheres - A hazardous oxygen-deficient atmosphere may develop in enclosed spaces where operations or processes consume oxygen or release asphyxiating gases or vapors into the atmosphere. Entry into any atmosphere containing less than 19.5% oxygen is considered hazardous.

C. Toxic/Corrosive Atmospheres - Hazardous toxic/corrosive atmospheres may be present where processes or operations generate airborne materials. Hazardous airborne materials include dusts, fibers, mists, fogs, smokes, fumes, gases, and vapors.

4.4.2.2 Confined Space Entry - In the absence of a specific technical operating procedure approved by the LSSO, work in confined spaces will be performed in accordance with the procedure described in KHB 1710.2 (V-2), "KSC Safety Practices Handbook."

4.4.2.3 Hazardous Atmosphere Areas for Electrical Equipment -

4.4.2.3.1 The hazardous atmospheric area for flammable liquids, such as propellants, are defined as follows:

A. Service carts, drums, storage vessels, or payload tanks - 50 feet radially from the container or as specified by the LSSO.

B. Vents - 50 feet radially from the vent opening.

C. Transfer lines - 25 feet radially from the line.

D. All installation configurations shall be evaluated for approval by the LSSO.

4.4.2.3.2 The hazardous atmospheric area for solid propellants is within 10 feet of any exposed propellant. Solid propellants are considered exposed when–

A. The motor nozzle is not attached and the nozzle end does not have a cover that precludes propellant offgassing or,

B. The nozzle is attached but does not have a nozzle plug installed sufficient to preclude propellant offgassing or,

C. Unassembled motor segments that do not have front and rear covers that prevent offgassing.

4.4.2.4 Requirements for Electrical Equipment in Hazardous Atmospheres -

4.4.2.4.1 When within areas prescribed in Paragraph 4.4.2.3 above, electrical equipment that is operated during system pressurization or flow of flammable propellants shall be either explosionproofed in accordance with the NEC (NFPA 70) or hazardproofed. Hazardproofing may be obtained by potting, hermetically sealing, or by positive pressurization with an inert gas or clean air as described in NFPA 496. The electrical equipment must be monitored at all times when powered.

4.4.2.4.2 Electrical equipment to be operated in enclosed rooms or areas where propellants are present but in a static state (i.e., no flow or change of pressurization) shall be controlled by a switch at a single monitoring station capable of deactivating all "nonexplosion/nonhazardproof" equipment within the area. This station must be manned at all times when the equipment is in use. The master switch shall be explosion/hazardproof if it is located within the hazard area. Equipment which cannot be connected to the master switch shall be identified to the LSSO during the phase safety review process.

4.4.2.4.3 Hazard groups for hazardous atmospheres are listed in the NEC (NFPA 70). For the purpose of this Handbook, kerosene (RP & JP fuels), oxygen, and solid propellants are to be considered Class I, Group D. Hydrazine is Class I, Group C.

4.4.3 Humidity

Any operations involving solid or liquid propellants or Category A EED's shall not be conducted at humidity levels below 30%. Exceptions shall only be approved by the LSSO on a case-by-case basis.

4.4.4 Toxic Materials

The LSSO and Biomedical Office will establish criteria for operational controls involving all toxic materials.

4.5 HANDLING AND TRANSPORTS

Many standards and guides list design requirements written to achieve a safe operation, such as Code of Federal Regulations, 29 CFR, "Occupational Safety and Health Administration, Department of Labor," Part 1910, and the "NASA Safety Standard for Lifting Devices and Equipment," NSS/GO-1740.9. The special nature of launch site safety mandates rigorous considerations in both design and process parameters.

The following definitions are to be used in this section:

A. Lifting devices - slings, linkage, mechanisms, etc., that extend between a lifting hook on a hoist and the object being lifted. Only those items below the lifting hook are intended to be designed to the criteria contained in this Handbook. The requirements for the design of hoists, winches, and cranes are not included. Other systems, if required, shall comply with the NSS/GO-1740.9.

B. Ground handling/transportation devices - trucks, dollies, transporters on which an object is placed for subsequent transportation or rotation.

C. Work stand - work platforms, ladders, etc., that are fixed structures, are designed specifically to support personnel, and do not experience the dynamic loading associated with lifting and transportation.

D. Support stand - GSE structure designed to support flight or ground equipment.

E. Rated load - the maximum static weight that the basic equipment can safely support or lift.

F. Working (actual) load - the expected or measured weight of a piece of equipment that is to be supported, lifted, or transported.

4.5.1 Hoisting and Handling

4.5.1.1 General - All payload organization lifting equipment and its usage must meet the requirements of 29 CFR, Part 1910; the American National Standards Institute, ANSI B30 Series, "American National Standard Safety, Standards for Cranes, Derricks, Hoists, Hooks, Jacks and Slings"; or the NSS/GO-1740.9, "NASA Safety Standard for Lifting Devices and Equipment" and the requirements herein.

A. All lifting and hoisting equipment must show evidence of the equipment having been tested in compliance with the above reference documents and the requirements of the paragraphs in this section. This must be accomplished within 1 year prior to use.

B. Records of all testing and inspections shall be maintained and shall be made available to the LSSO upon request.

C. Rated loads will be posted on all lifting and hoisting equipment and fixtures.

D. Magnetic particle, dye penetrant, radiography, or other suitable crack-detecting tests shall be performed on all load-bearing hooks, shackles, and eyebolts after the initial proof test of the assembled sling but prior to use and annually thereafter. The nondestructive inspection (NDI) method selected will require approval by the LSSO during the phase safety review process. A defect-detecting method such as radiography or ultrasonics which evaluates the material through 100% of its depth shall be performed on all welds constituting a single point of failure (i.e., critical weld) after the initial proof test of the assembled sling. Critical welds shall be eliminated where feasible. If the payload organization certifies that their lifting hardware is for a specific function, is properly controlled in terms of usage/misusage and the environment, and has undergone a thorough NDI prior to application of a protective coating, the LSSO may not require an annual NDI.

E. Thimbles, shackles, links, eyebolts, swaged fittings, wire ropes, and similar devices must be subjected to and comply with the testing, preoperational and periodic inspection, and maintenance requirements set forth in the applicable ANSI B30 Series or the NSS/GO-1740.9. Eyebolts which are permanently fixed to the load are to be considered exempt from proof loading and NDI requirements. However, the eyebolts must comply with the design requirements of Table 4-1.

F. Eyebolts that can be removed and replaced must have a positive means of determination of full thread engagement (i.e., shoulder, color marking, etc.).

G. Attach points to payloads for the purpose of ground handling shall be classified as either utilizing the flight structural interfaces to the Orbiter or having special attach fittings for the purpose of ground handling. When utilizing the flight attach fittings for ground handling, structural analysis shall not be required if this determination has been made for flight dynamics. When special fittings for ground handling are used, an analysis shall be conducted to ensure the load paths have adequate safety factors for ground handling. The attach points (S/C) and fittings (GSE) shall be adequately described in the safety data package, including single failure points, verification methods (e.g., proof testing, NDI), and the methods used to assure proper connection during ground handling.

H. Proof loading and associated NDI will be reaccomplished for modified or repaired lifting equipment.

I. In accordance with 29 CFR, Part 1910, a load will not be lifted, suspended, or transported over personnel. This requirement should be considered during design of GSE for hardware integration and assembly.

4.5.1.2 Requirements for Slings -

A. Slings shall be designed and tested as an assembled unit (unless otherwise approved by the LSSO) which includes spreader beams and drop legs (ropes, chains, shackles, eyebolts, pins, turnbuckles, etc.) in accordance with Table 4-l. Proof or periodic load test shall be accomplished within 1 year prior to use.

Table 4-1 Sling Requirements

SLING COMPONENT	SAFETY* FACTOR (ULTIMATE:RATED)	PROOF TEST (PROOF:RATED)	PERIODIC LOAD TEST (TEST:RATED)	
			NASA/KSC	DOD**
Wire Rope	5	2	1.25	2
Alloy Steel Chain	5	2	1.25	2
Metal Mesh	5	1.5	1.25	2
Natural or Synthetic Web	5	1	1	1
Natural or Synthetic Rope				
Manila	5***	1	1	1
Polypropylene	6***	1	1	1
Polyester	9***	1	1	1
Nylon	9***	1	1	1
Structural Members (e.g., spreader beams)	5****	2	1.25	2
Shackles, Turnbuckles, Eyebolts, etc.	5	2	1.25	2

* As relates to this table, safety factor is defined as the ratio of a load that predicts a failure to a rated load.

** DOD ownership, sponsorship, or at a DOD location.

*** Use of rope slings will be limited to 50% of the rated capacity (manufacturer's rating).

**** A 3:1 safety factor against the worst case failure mode that will result in local yielding is acceptable.

B. All sling assemblies shall be visually inspected each day prior to use. A periodic inspection shall be performed by the using organization on a regular basis with frequency of inspection based on frequency of sling use, severity of service conditions, nature of lifts being performed, and experience gained on the service life of slings used in similar circumstances. Periodic inspections shall be performed by an authorized person. Any deterioration which could result in appreciable loss of original strength shall be carefully noted, and determination made whether further use of the sling would constitute a safety hazard. Periodic inspections shall be conducted annually, as a minimum.

C. Wire rope slings shall be immediately removed from service if any of the following conditions are present:

1) Ten randomly distributed broken wires in one rope lay or five broken wires in one strand in one rope lay.

2) Wear or scraping of one third the original diameter of outside individual wires.

3) Kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure.

4) Evidence of significant heat damage.

5) End attachments that are cracked, deformed, or worn.

6) Hooks that have been opened more than 15% of the normal throat opening measured at the narrowest point or twisted more than 10 degrees from the plane of the unbent hook.

7) Significant corrosion of the rope or end attachment.

D. Structural sling inspection shall be performed at least annually. Discrepancies found during the following inspections shall be cause for replacement or repair:

1) Verify, overall, that there is no evidence of visual damage, gouges in metal, flaking paint, loose bolts, rivets, or connections, or deformation such as galling or gouges in pins, eyes, and end connections.

2) Ensure that there are no bent, deformed, cracked, or excessively corroded support or main members.

3) Inspect load-bearing bolts and verify that there is no visual evidence of bending, cracking, gross wear, or improper configuration.

4) Inspect attached and lifting lugs for visual deformation and evidence of local yielding.

5) Ensure that there are no elongated attach or lifting holes.

6) Inspect around fasteners for local yielding and deformation.

7) Remove and inspect load-bearing slip pins for visual deformation, evidence of bending, abnormal defects such as galling, scoring, brinelling, and diameters not within drawing tolerances. NDI shall be used when required by design requirements or when cracks are suspected.

8) Inspect pin bores visually for cracks, deformation, local yielding, scoring, galling, and brinelling. NDI shall be performed as required.

9) Inspect welds for cracks and evidence of deformation, deterioration, damage, or other defects by–

a. Visual inspection of all welds.

b. Magnetic particle, x-ray, or other suitable crack-detecting methods as appropriate for critical welds as identified on the drawings.

10) Inspect all parts, particularly bare metal, for corrosion. Corrosion-protect all surfaces that are to be painted, lubricated, or coated with strippable vinyl, as necessary. Do not paint over uninspected areas; do not paint over cracks, deformations, deterioration, or other damage until engineering assessment has been made.

E. For identification and on-site assurance purposes, equipment shall have a periodic recertification tag containing equipment identification, next required test date, and quality control stamp. Hoists/winches and slings shall have proof load tags containing rated load, proof load, and proof load date.

F. Slings which have components that are normally disassembled shall be either marked, coded, or tethered to assure proper assembly of verified hardware. Components not marked, coded, or tethered will invalidate the proof load/certification of the whole assembly. Removable lifting lugs used on flight hardware or GSE must be identified to ensure the lugs can be reinstalled in the proper location if necessary.

G. Synthetic or natural rope slings shall be derated by 50% after the proof load; this then becomes the rated load; i.e., manufacturer's rating x 1.0 (proof test factor) x 0.50 (derating factor) = posted rated load.

4.5.1.3 Hydrasets - Hydrasets shall be initially load tested to 200% and annually thereafter to 125% of their rated load. Hydrasets shall be tested to 125% whenever seals are replaced. Manufacturer's certification of test is acceptable for either new or reworked hydrasets. The piston rod must be fully extended for load test. An operational test of the pump shall be done every 6 months.

4.5.1.4 Chainfall - Chainfalls shall be initially and annually load-tested to 125% of rated load.

4.5.1.5 Load cells - Load cells shall be annually load-tested and calibrated to 100% of their rated load.

4.5.1.6 Stands -

A. Ground handling devices and support stands shall have a safety factor of 3:1 against yield.

B. Personnel work stands shall have a safety factor of 4:1 against ultimate.

C. A one-time proof test and NDI of support stands shall be required based upon hazard potential. The proof test level shall be at least 1.25 times the rated load. An LSSO-approved NDI shall be performed after the proof test. A proof test and NDI shall be required after misuse or modification.

4.5.2 Transporters

A. Prior to use, checks will be made to ensure–

1) Proper tire inflation.

2) An operable braking system.

3) Tow bar and safety chains are properly fastened.

4) Payload securing devices are properly tightened.

5) Availability of wheel chocks.

6) Availability of fire extinguisher(s).

B. Maximum speed shall be prominently and permanently displayed on both the front and rear of the transporter.

C. Transporters shall be parked only in approved areas.

D. Movement of transporters carrying liquid fuel, solid motors, or installed ordnance shall comply with AFR 127-100 and not commence when electrical storms are within 5 miles.

E. Transporters shall have a safety factor of 3:l against yield; however, commercially available equipment (e.g., flatbed trailers) are acceptable.

5.0 MISHAP INVESTIGATION AND REPORTING

5.1 NASA MISHAP INVESTIGATION CONTROL

Reporting and investigation for mishaps involving NASA payloads and associated GSE will be conducted under the provisions of NHB 1700.1, "NASA Safety Manual," Volume 1, and NASA Management Instruction, NMI 8621.1, "Mishap Reporting and Investigating." Investigation of mishaps involving NASA-sponsored (non-USAF) payloads and associated GSE occurring after arrival at NASA facilities will also be conducted under the same provisions.

5.2 USAF MISHAP INVESTIGATION CONTROL

Reporting and investigation of mishaps involving DOD or foreign military payloads or personnel will be controlled by AFR 127-4, "Investigating and Reporting USAF Mishaps."

5.3 MISHAP REPORTING

5.3.1 Mishap Contacts

The payload organization shall immediately report to the LSSO mishaps which result in death or injury/exposure of personnel or damage to resources, equipment, or facilities. Close calls shall be similarly reported. The LSSO mishap point of contact is as follows:

A. For NASA-sponsored payloads at the ELS: KSC Safety Operations Division, Payloads and Industrial Safety Processing Branch (RT-SAF-2). Further requirements are outlined in KHB 1711.1, "Reporting and Investigation of Mishaps," paragraph 2.2.3.

B. For DOD-sponsored payloads at the ELS: 45 SPW Safety Office, Payloads Branch (45 SPW/SEMP).

C. At contingency landing sites: The designated on-site LSSR.

Note: In the event that the mishap involves the release of and/or exposure to hazardous chemical agents, the Biomedical Office representative will be notified in addition to the LSSO.

D. Facility operators involved with or observing a mishap shall notify their safety point of contact.

Note: The LSSO mishap point of contact, above, is responsible for further notification to other LSSO mishap points of contact as necessary.

5.3.2 Payload Organization Involvement

The payload organization is responsible for investigating all mishaps and anomalies with which they may be involved, to the extent of their involvement.

5.3.3 Payload Organization Responsibilities

For mishaps involving payload organizations, the following defines investigation and written reporting responsibilities:

A. If government personnel/property, including contractors, are injured/damaged from or contribute to the mishap, then the payload organization shall report as follows:

1) A preliminary written report of the mishap to the LSSO mishap point of contact within one working day after the mishap occurs.

2) Further reporting and investigation will be conducted in accordance with KHB 1711.1 or AFR 127-4, as appropriate. The payload organization may be requested to conduct its own investigation concurrently with the government investigation.

3) The payload organization will provide a copy of the final report to the LSSO mishap point of contact.

B. If only payload organization personnel/property, including payload organization contractors, are injured/damaged from or contribute to the mishap, and the mishap is not considered a near miss to government property/personnel, then the payload organization shall report as follows:

1) When the LSSO mishap point of contact is notified, the need for a preliminary written report will be determined.

2) Investigation shall be done by the payload organization using its own internal procedures.

3) A copy of the final report of the mishap investigation shall be sent to the LSSO mishap point of contact for Lessons Learned purposes.

5.3.4 Investigation Boards

A government-directed investigation board, when convened, is responsible for the official investigation report. All other investigation and reporting activities will be under its control. Concerned organizations and element contractors shall cooperate fully in a mishap investigation, providing records, data, administration and technical support, and services requested by the investigating board/official.

5.3.5 Mishap Scene

The scene of the mishap shall not be disturbed until the investigating authority has given concurrence to do so.